Electric Feedback Forum
Office of Governor Martin O'Malley
Improving Maryland's Electric Distribution System

Roundtable Discussion #5: Other Investments on the Utility Side of the Meter

Sept. 6, 2012, 1:30pm – 4:30pm
President's Conference Room East 1 and 2
Miller Senate Office Building
11 Bladen Street
Annapolis MD, 21401

Executive Order 01.01.2012.15

List of Invited Participants

Brian Deaver, Technical Executive, EPRI

Sunil Pancholi, Director of Strategy, Lockheed Martin Energy Solution

Bruce Walker, Davies Consulting

Christopher Burton, Vice President, Smart Grid and Technology, BGE

Robert S. Stewart, Manager, Advanced Technology and New Business, PHI

Summary of testimony – Reliability and Resiliency

Davies Consulting LLC, a Maryland-based strategic energy consulting company, would like to thank Governor O'Malley for providing the necessary leadership to guide this discussion on the safe and reliable delivery of energy services to the citizens of Maryland. Davies Consulting has had the opportunity to work extensively with major utilities in Maryland and across North America that are dedicated to providing quality services to their customers and we welcome the opportunity to participate in this roundtable discussion.

Reliability and resiliency are key areas of focus within the utility industry. Each year, utilities invest hundreds of millions of dollars throughout Maryland to provide service to customers. Some of these investments are focused on providing reliable service (ensuring that the system has adequate power available for customers) and some are focused on making the system more resilient (the ability of the utility to continue to operate despite damage to parts of its system). The key to optimizing capital spending made by utilities requires that they maximize the value created by each investment. While focusing on reliability and resiliency, utilities are challenged to modernize and evolve a system from one designed to simply deliver power from the generator to the end-user to one that delivers power via a more dynamic multi-directional, flexible, and adaptive system. In addition to evolving the grid, investment decisions must also consider impact on safety, the environment, power quality, and the aged asset base. Ideally, each investment addresses many of these considerations simultaneously.

As noted above, reliability focuses on ensuring the availability of the appropriate amount of power at any moment. The overall reliability of an electric system is highly correlated to its design, i.e., overhead versus underground and looped overhead versus radial overhead systems. Each of these system designs has its benefits, risks, and costs. Hereto, resiliency is also highly correlated to a system's design. And thus the two criteria: reliability and resiliency must be evaluated concurrently.

The key to enhancing reliability and resiliency is to understand the root causes for events that adversely affect integral system components and cause system outages and subsequent restoration. Once this information is known, solutions – whether system design modifications, operational improvements, or equipment upgrades – can be developed. The information necessary to conduct an accurate root cause analysis to determine why power is being interrupted and the effectiveness of the restoration can be captured several ways, including: asset management processes to fully understand the assets; and correlation and signature modeling using data captured via advanced monitoring. In short, reliability and resiliency cannot be addressed unless there is a thorough understanding of the causes for deficiencies.

Notwithstanding the need to understand the root causes of events, some investments are better than others. Both reliability and resiliency are dependent upon exposure of the system to a variety of hazards. Thus, investments that are focused on making the electric system as discrete as electrically possible, without compromising overall reliability or operability, will ultimately tend to increase the overall reliability and resiliency of the system. For instance, it is reasonably accepted in the industry that an investment in a bi-directional recloser (and coordinated downstream fusing) will, over time, improve both reliability and resiliency in a

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cost-effective way. Deployed properly, a recloser improves safety by providing a responsive isolation device, significantly improves reliability for the customer by reducing a specific circuit's SAIFI, and improves resiliency by allowing additional switching opportunities (when looped) to provide source power during restoration efforts, thereby minimizing the overall impact of an initiating event, and potentially reducing the fault exposure time for equipment thus extending its useful life.

The reliability and resiliency of an electric system may be improved through a thorough understanding of the root causes of events and key investments focused at specifically resolving these root causes. It is crucial that processes and advanced monitoring are utilized to identify and address system conditions that result in reduced reliability and compromised resiliency. In addition, investments can also be made that, not only improve reliability and resiliency, address aged infrastructure issues, facilitate the integration of renewable and distributed technology, improve utilization of equipment, improve safety, and address environmental concerns, but also improve power quality.

The focus on reliability and resiliency may ultimate require a new business model and regulatory compact.

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Recommendations for Maryland Electric Utility Roundtable – Reliability and Resilience

In sum, utilities can focus on making "foundational investments" that establish, with each investment, the platform necessary to transition the 20th Century grid to be able to integrate and benefit from the technological advances of the 21st Century.

Short-term Recommendations:

- Implement ***intelligent two-way power flow devices*** with sophisticated monitoring to manage present and future system conditions system-wide. These devices include reclosers, switches, breakers, and substation circuit switches used to manage the system more efficiently and proactively from generation to end-use.
- Adopt ***self-isolating system designs***, including loop systems and other multi-dimensional designs that provide options for managing and optimizing the system.
- Use ***Volt/VAR control*** to maximize the use of resources, reduce generation, focus on providing high quality power, and minimize line and transformer losses.

Long-term Recommendations:

- **Design**
  - Update the design basis and design the overhead system to be better adapted to the environment it is in – undergrounding is not the solution; different system, wire and pole designs are.
  - Increase penetration of renewable and distributed generation technologies to enable multi-point power flows with appropriate monitoring and modeling/operational algorithms; consider the diversity and reliability improvements realized through the use of micro/mini grids because the electric grid's infrastructure as we know it and rely on it today, should not exist in 50 years.
- **Technology and Systems**
  - Promote and accelerate a ubiquitous broadband solution for non-critical infrastructure to provide the platform upon which the communications required for the advancement of the electric grid (and various other energy and infrastructure opportunities) may be realized.
  - Implement improved modeling software that integrates all necessary information from monitoring devices and optimizes the utilization of resources; focus on optimized asset utilization, improved power quality, efficiency, and reliability.
- **Business Processes**
  - Use sophisticated monitoring, correlation algorithms, and appropriate utility processes to conduct best practice asset management; use intelligent electronic devices to respond to system events automatically; increase sophisticated monitoring to predict equipment failure
  - Adopt a regulatory and market design that capitalize on advanced software, automation, and control systems, and require customers to pay actual costs to encourage user reduction during peak period; thereby eliminating much of the present-day expense that is designed to meet peak usage for a period of approximately 120 hours each year.

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- Embrace a regulatory design that meets the present-day challenges of *maintaining and modernizing* a ubiquitous and multi-direction power flow, yet aged electric system, instead of one that focuses on capital investment, which was designed to encourage the development of the electric grid.

Distribution Systems
Grid Resiliency

Brian J. Deaver, Sr., P.E.
Technical Executive

Power Delivery and Utilization

September 6, 2012

Session IV: Other investments on the utility side of the meter

Our History…

- Founded in 1972
- Independent, nonprofit center for public interest energy and environmental research
- **Collaborative** resource for the electricity sector
- Major offices in Palo Alto, CA; Charlotte, NC; Knoxville, TN
  - Laboratories in Knoxville, Charlotte and Lenox, MA

Chauncey Starr
EPRI Founder

Grid Resiliency – Resilient from what?

Physical Infrastructure

Information Infrastructure

Key to Resiliency: Prevention, Recovery, Survivability

Prevention: Now and Opportunity for Future Technologies

Vegetation Management

Selective Undergrounding

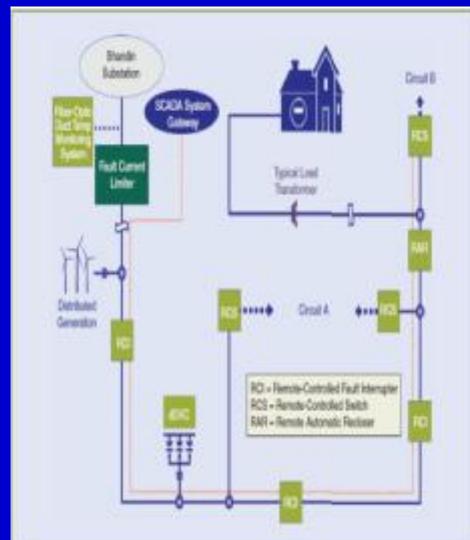
Pole and Line Design

Hydrophobic Coating

Benefit/Cost for Each Option Needs to be Factored for Storm Hardening

Recovery: Now and Opportunity for Future Technologies

Using UAVs for damage assessment



Courtesy: Southern California Edison

Automated Restoration & Reconfiguration

Improved Sensing & Situational Awareness

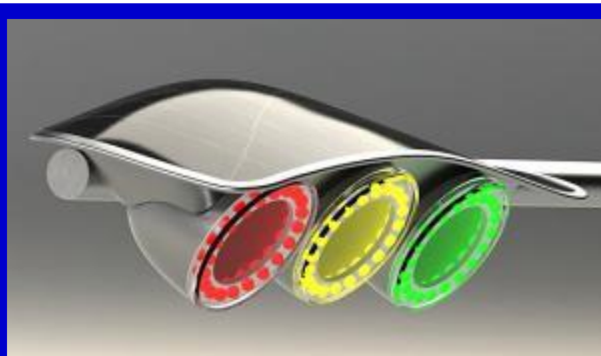
Deploy Sensing, Communications & Control Technology to Speed Restoration. Leverage new assessment technologies.

Survivability: Leveraging New Technologies

EV Power Source

Courtesy: Nissan

Micro Grid



PV+Storage+LED Traffic Lights

Solar Chargers for Cell Phones

Continuation of Essential Missions even after the Grid has Failed

Courtesy: Carnegie Mellon Electricity Industry Center (CEIC).

Distribution Grid Resiliency

- Prevention
- Recovery
- Survivability

Opportunity for Improving All Three Aspects of Resiliency Through Integrating New and Existing Technologies

Investments on the Grid Impact…

Prevention

- Distribution Automation
- Enhanced Protection on Laterals
- Reduction of OH Exposure
- Sensing – Distribution Fault Anticipation

Recovery

- Distribution Automation
- Automated Restoration
- Improved Switching on Mains
- Fault Indication

Survivability

Investments to be Considered

- Distribution Automation (Prevention & Recovery)
  A system of automated switches/sectionalizers/reclosers deployed with sensing and two way communications to enable faults on the feeder mains to be quickly isolated and restored via remote control, and provide visibility into the control room about switch status, faults detection, loading, etc.
- Automated Restoration (Recovery)
  A software enabled solution that automates the restoration decision making and switching direction of a Distribution Automation system
- Increased Switching / Sectionalizing (Recovery)
  Provision of additional manual switching devices on the feeder mains to improve the ability to do partial restoration of service.
- Enhanced Protection on Feeder Laterals (Prevention)
  Deployment of advanced protection devices (cut out mounted electronic sectionalizers or reclosers) on laterals to reduce sustained outages.
- Fault Indication (Recovery)
  Deployment of sensors to detect and alert field crews about the location of faults on OH or URD systems.
- Sensing – Distribution Fault Anticipation (Prevention)
  Deployment of sensors to monitor current and voltage at key switching locations to identify indicators or precursors of impending failures.
- Reduced Exposure / Optimized Configuration (Prevention)
  Reliability focused analysis of feeder configurations to identify opportunities to reduce exposure to faults and/or minimize the number of customers impacted by each fault.

What? Where? How Much?

- To properly assess the “right answer” as to what to do, where to do it, and how much to do, analysis of the benefits of each investment must be made taking into account the specific situation of the utility and feeders being considered.
- Several metrics have been used to compare different reliability improvement investments:
  - Dollars / Customer Impacted
  - Dollars / Customer Minute of Interruption Avoided
  - Dollars / Sustained Customer Interruption Avoided
- A proper analysis of what investments to deploy will likely result in a mix of solutions being deployed.

Summary

- Multiple options exist for distribution grid investments to improve reliability of service.
- The “right answer” is likely a mix of investments and may differ between utilities, geographic areas and individual feeders.
- An analysis of the benefits ($ per reliability metric improvement) verses costs is required to craft the proper investment.

Together…Shaping the Future of Electricity

LOCKHEED MARTIN

Other investments on the utility side of the meter

Reliability and Resiliency of Maryland's Electric Distribution System

Sunil Pancholi
Director – Strategy
Lockheed Martin

September 6, 2012

Investments to Increase Reliability and Resiliency

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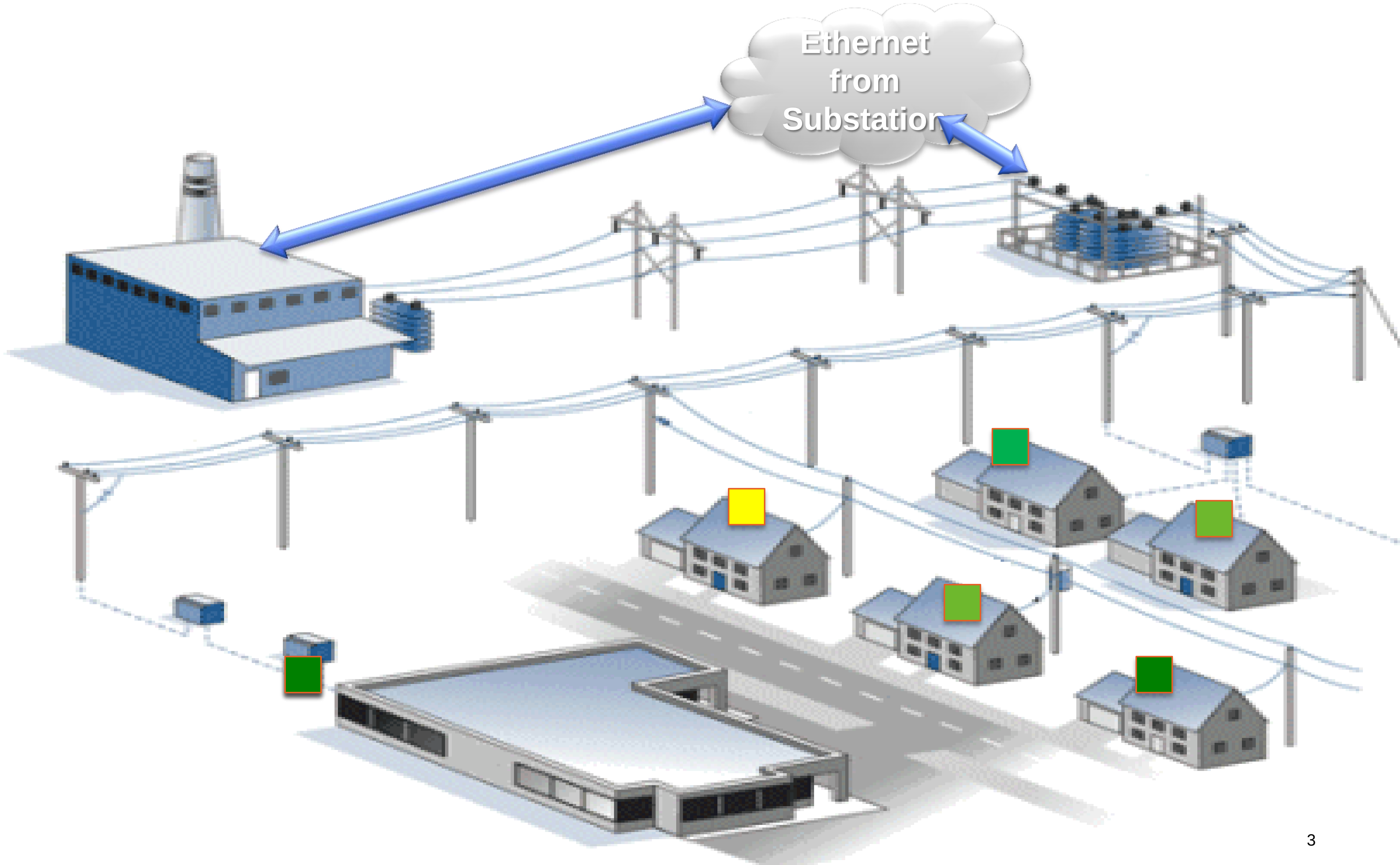
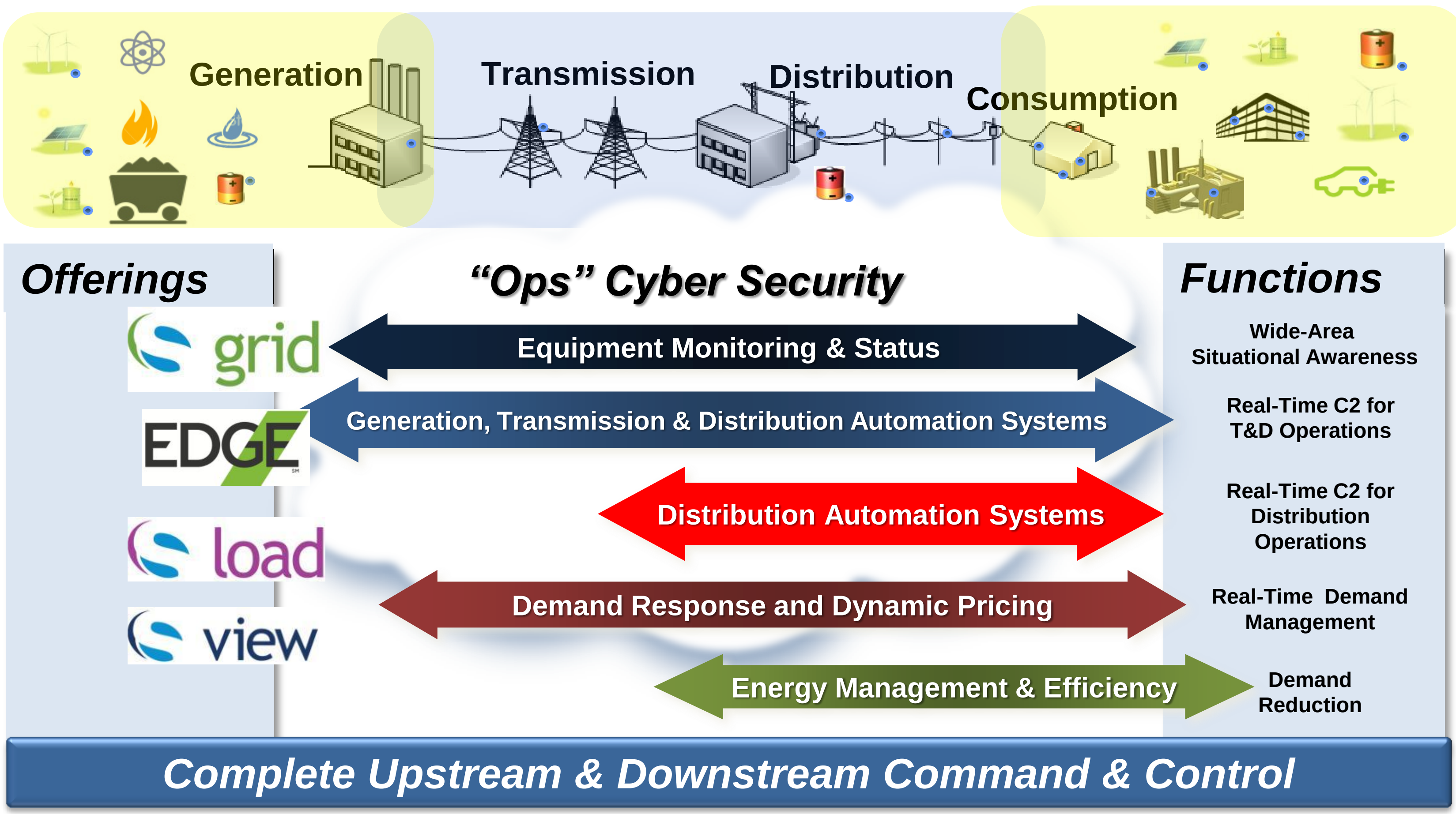
- Intelligent Grid
  - AMI/Smart Meters
  - Smart Relays
  - Automatic Feeder Sectionalizing and Reclosing Switches
  - Accurate Customer Premises – Grid Location Aware
- Net-Centric Technologies
- Distributed Energy Resources – PMU Monitoring
- Cyber Security
- Outage Restoration Maturity Model

Accurate Customer Premises – Grid Location Aware

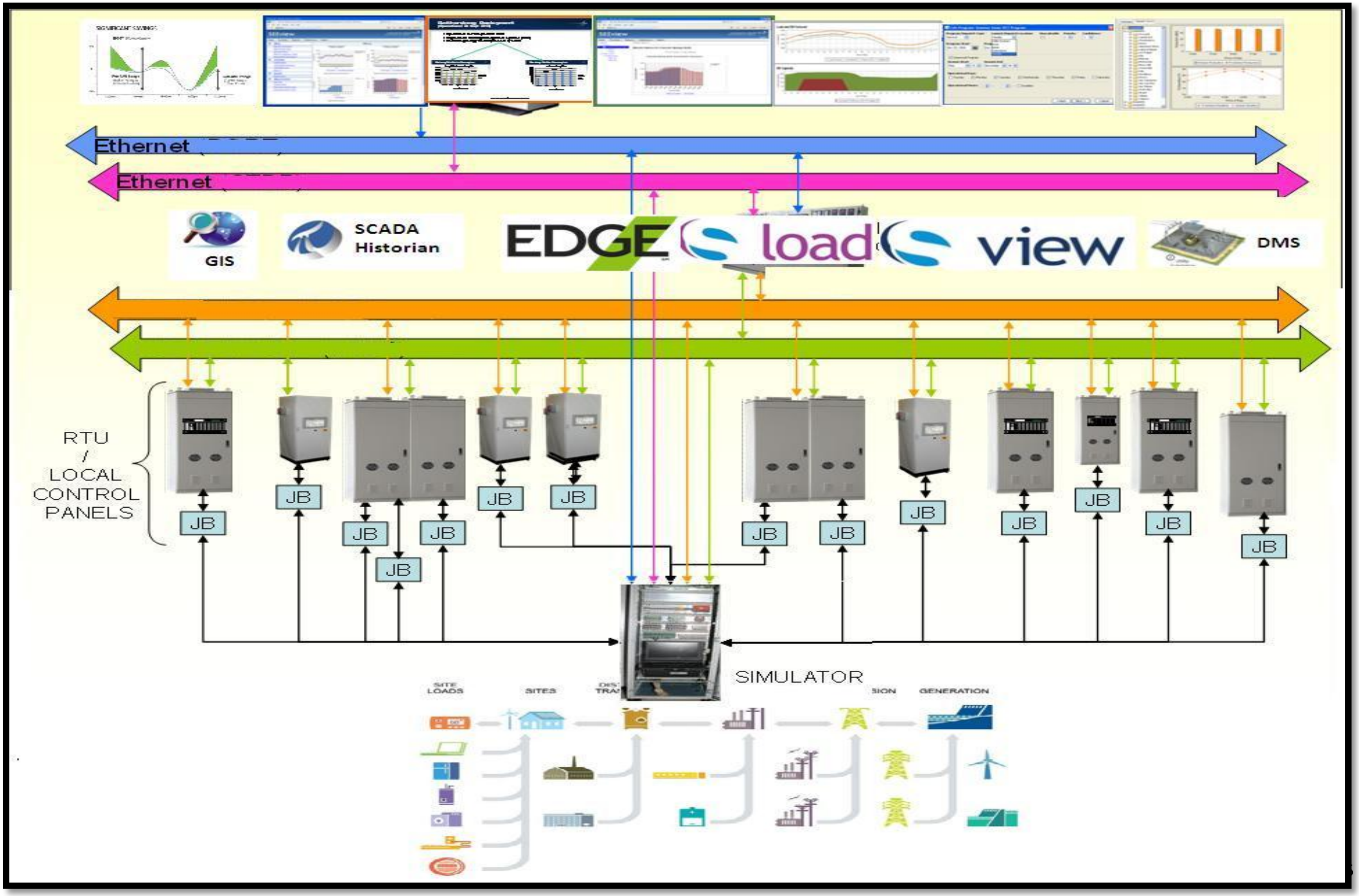


Net-Centric Technologies
Integrating OT and IT through C2

- Unique Command & Control (C2) Experience – the ability to not only correlate varied data sets, sensors and assets, but provide ***automated*** course of action enabling ***real-time decision making*** improving system efficiency and reliability

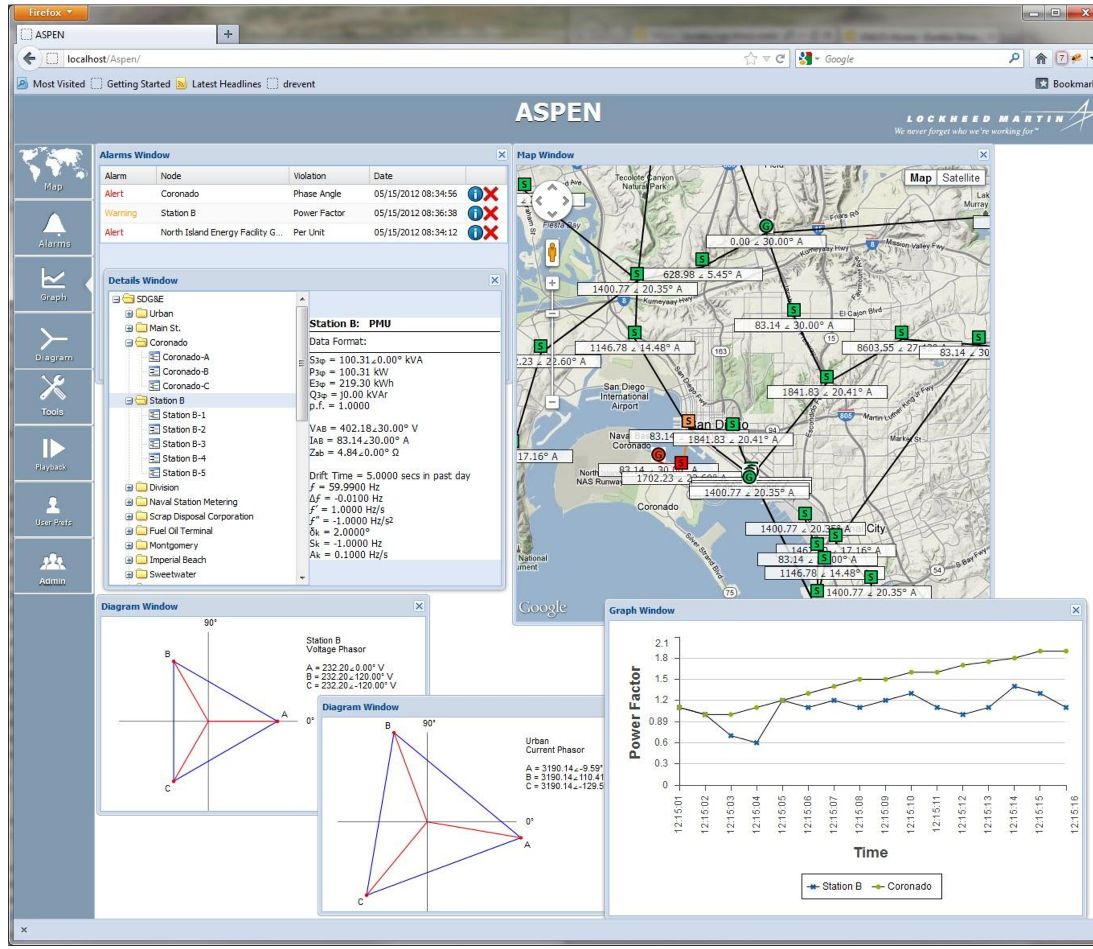


Net-Centric Technologies
Integrating many discrete systems



Distributed Energy Resources PMU on Network

- PMUs are placed where there are significant installations of customer side Distributed Generation (DG)
- Focus of PMUs is to monitor customer side non-dispatchable DG
- Provides early warning of generation loss to multiple subsystems
  - ➢ Demand Response and Intelligent Storage to firm generation loss
  - ➢ Distribution Management System to balance circuit(s) w/fixed generation
  - ➢ Other protection systems as necessary
  - ➢ Improves the reliability of distribution systems



Cyber Security: The Challenge

Generation | **Transmission** | **Distribution** | **End users**

- Distributed Energy Resources (DER)
- Advanced monitoring and diagnostics
- Wide Area Measurement
- Automation
- Volt/VAR Control
- Smart Metering / AMI
- Demand Side Mgmt

Obvious Trends Driving Smart Grid

- Energy Generation Alone is Not Sufficient to Meet Demand
- Energy Efficiency Methods Require More Information and Control
- Renewable Generation Sources Require Modern Grid Connection and Control

= MORE DATA!

Smart Grid deployments will bring over 250 million new "hackable" points in the US within the next 5 years *(Pike Research)*

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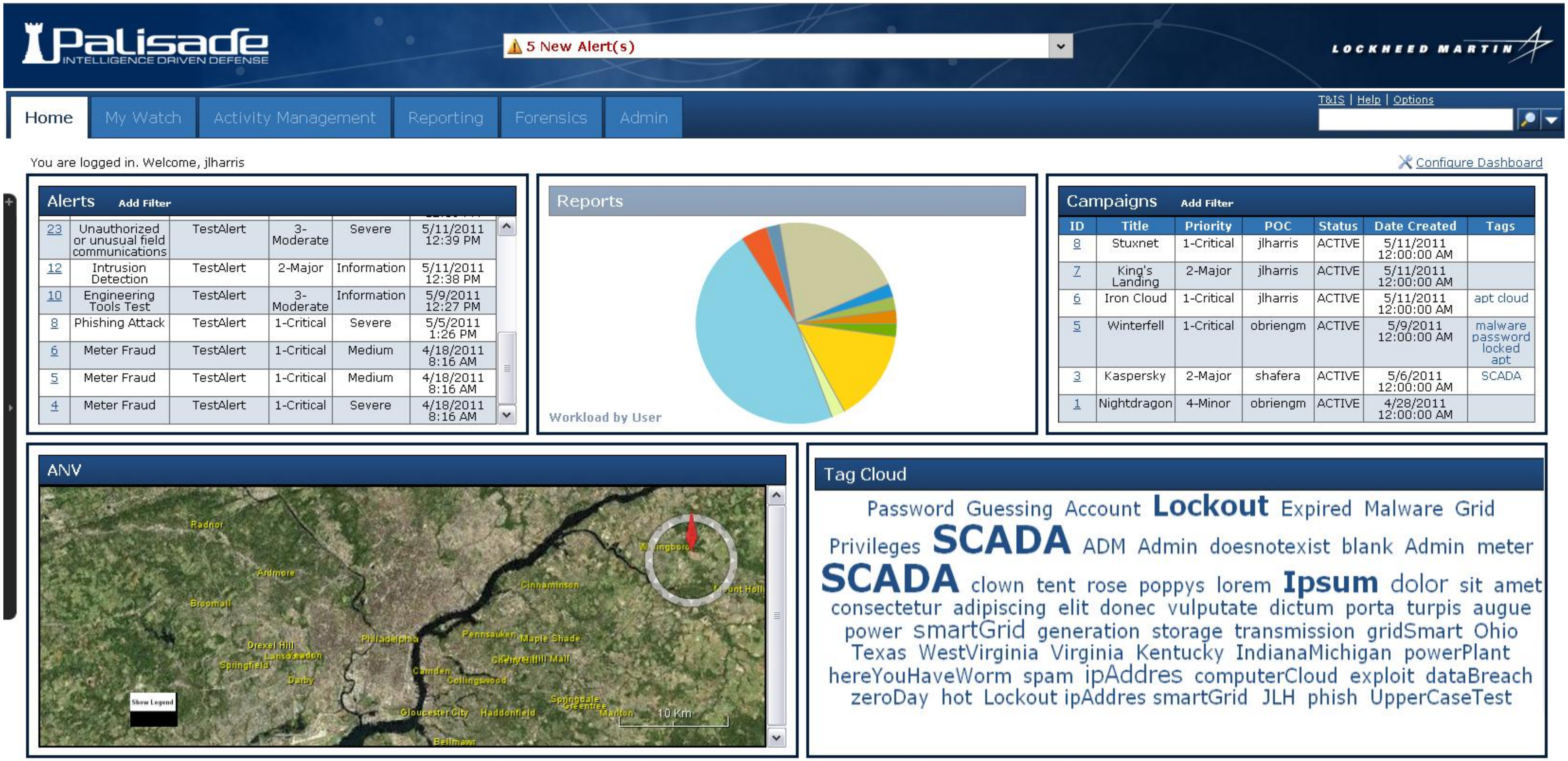
Cyber Security – LM Palisade



Cyber Security: Electric Utility Threat & Info Sharing

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The Challenge

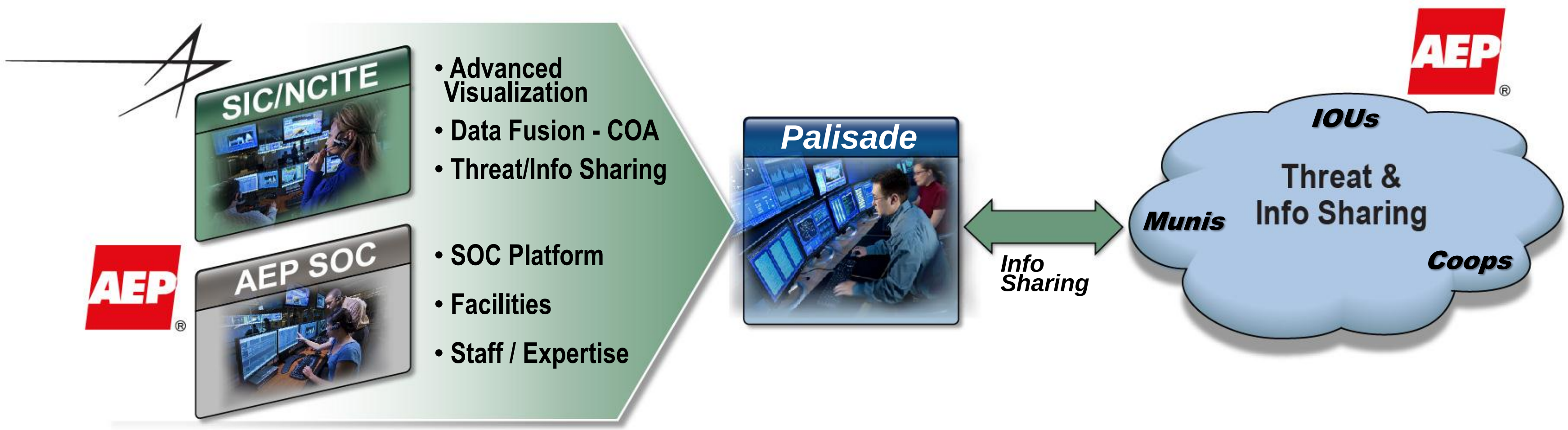
- Ensuring Smart Grid Systems are Secure
  - *Critical Assets, Information, Operations*
- Ensuring Compliance with Critical Infrastructure Protection (CIP) Standards

Key Questions

- Are Deployed Smart Grid Solutions Secure?
- How do I ensure 24x7 Protection of my Enterprise?

Approach

- Leverage Lockheed Martin experience and technologies defending Intelligence Community and DoD systems
  - *Security Intelligence Center (SIC)*
  - *NCITE*
- Enhanced Situational Awareness … enabling operators to make more informed decisions
  - *Lockheed Martin*
  - *AEP*
  - *Strategic Alliances*

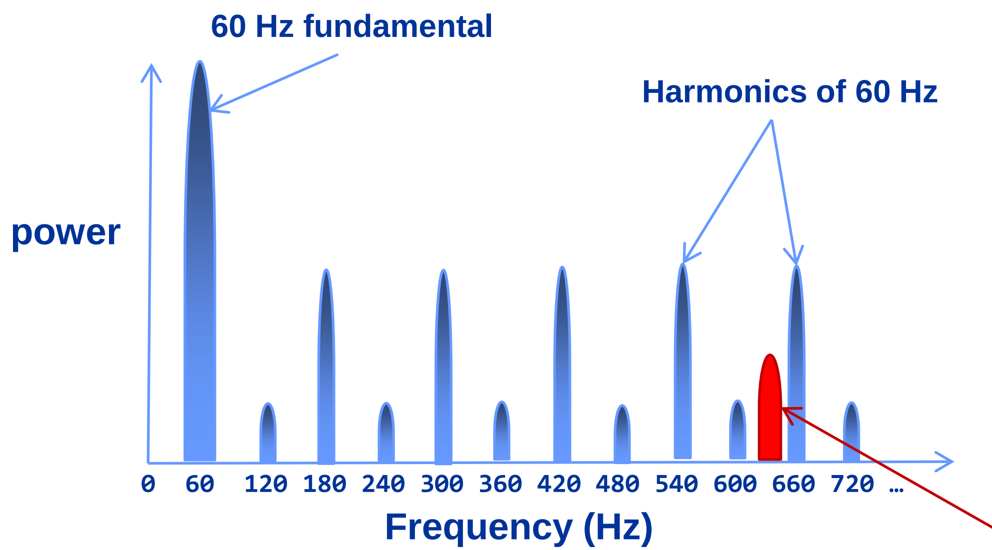


Outage Restoration Maturity Model

- Benchmarking Tool
- This model in development by Utility Operations/ Emergency Restoration staff (four US utilities) and an Information Technology Company in Virginia
- A capability framework for self-assessment of current state and plans for continuously improving outage restoration processes
- The model identifies 44 focus areas and 158 functions that are critical to outage restoration. The scoring provides a maturity level rating.
- Scoring Spectrum
  - > 300 Optimized/Mature State
  - 151-300 Managed State
  - < 150 Evolving State

Appendix

Accurate Customer Premises – How Grid Location Aware (GLA) Works



- Frequencies in between odd harmonics of 60 Hz have little signal interference from power system
- Inject a carrier in clear frequency areas
- Injected carrier is modulated to transmit a data signal

Injected PT communication signal (notional freq choice)

Technical Characteristic	Impact on System Performance
Approach uses very low frequencies (by comms systems standards)	Allows signal to propagate through transformers but limits amount of data that can be sent
“Always on” connectionless approach	No per-node setup/teardown overhead as with AMI; low latency
Shared channel between many nodes	Scales to large numbers of nodes, but total message size/volume must be kept low (report by exception only)
Wires not designed for higher than 60 Hz signal propagation	Channel distortion may require adaptive correction to achieve desired data rates

SEEsuite Solution Portfolio

	Application Benefit	Competitive Advantage	Value Proposition
EDGE	Voltage Optimization	Granular, Adaptive & Verifiable	Demand & Energy Savings
load	Advanced Load Management	Multi-Platform Integration	Next-Gen Load Control
view	Enterprise Energy Management	Hardware Agnostic	Energy Usage Optimization

SEEsuite Smart Grid C2

Scalable & Secure Platform for Grid Reliability & Energy Optimization

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